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DEBARKING CHIPPED LOGGING RESIDUES:

TECHNIQUE AND POTENTIAL IMPACT

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ABSTRACT

Woods-run samples of four Intermountain species (western larch, Douglas-fir, ponderosa pine, and lodgepole pine) were chipped separately, then processed through the chip debarking system developed by the Forest Service's Forest Engineering Laboratory at Houghton, Michigan. When the chips retained for each species were mixed together, bark content ranged from 1 percent for lodgepole pine to 7 percent for western larch. Bark removal ranged from 60 to 85 percent, wood loss from 8 to 13 percent.

INTRODUCTION

One of the most promising approaches to intensive utilization of logging residues is to chip cull trees and logging slash in the woods by means of small, mobile chippers, then transport the chips to manufacturing plants that utilize wood fiber. In a recent study in Wyoming (Benson 1974), this system increased by 35 percent the wood fiber that would have been recovered by conventional logging alone.

Despite the advances in chipping and residue handling equipment, the chipping of forest residues on a large scale in the Intermountain West has not generated much interest. One of the main reasons is that current models of mobile chippers produce barky chips that do not meet industry specifications for many products. Barky chips face low demand at prices that do not cover the costs of chipping and transportation. Until a method for debarking the chips is devised, intensive utilization of waste wood in the Intermountain area will remain economically unattractive.

The Forest Engineering Laboratory, Houghton, Michigan, has recently developed a system that will remove bark from chipped residues (Arola and Hillstrom 1972; Arola and Erickson 1973; Hillstrom 1973). The system has recently been applied to chipped whole trees and logging residues from Intermountain species--Douglas-fir, western larch, ponderosa pine, and lodgepole pine. This report presents the results of the study and projects the potential impact of implementing chip debarking on a regionwide basis.

Figure 1 shows forest residues in overmature lodgepole pine stands on the Bitterroot National Forest. In many instances, volumes in these stands are divided a third green, a third dead standing, and a third down. Figure 2 shows the same stand after partial logging. The foreground has 960 cubic feet, or 14.4 tons, per acre of residue. Logs in the background have not yet been skidded out. Utilization was down to 2.5-inch top diameter. In contrast, figure 3 shows logging residues of 70 tons per acre, after burning slash in mixed spruce-fir, where utilization was down to 6-inch minimum top diameter.

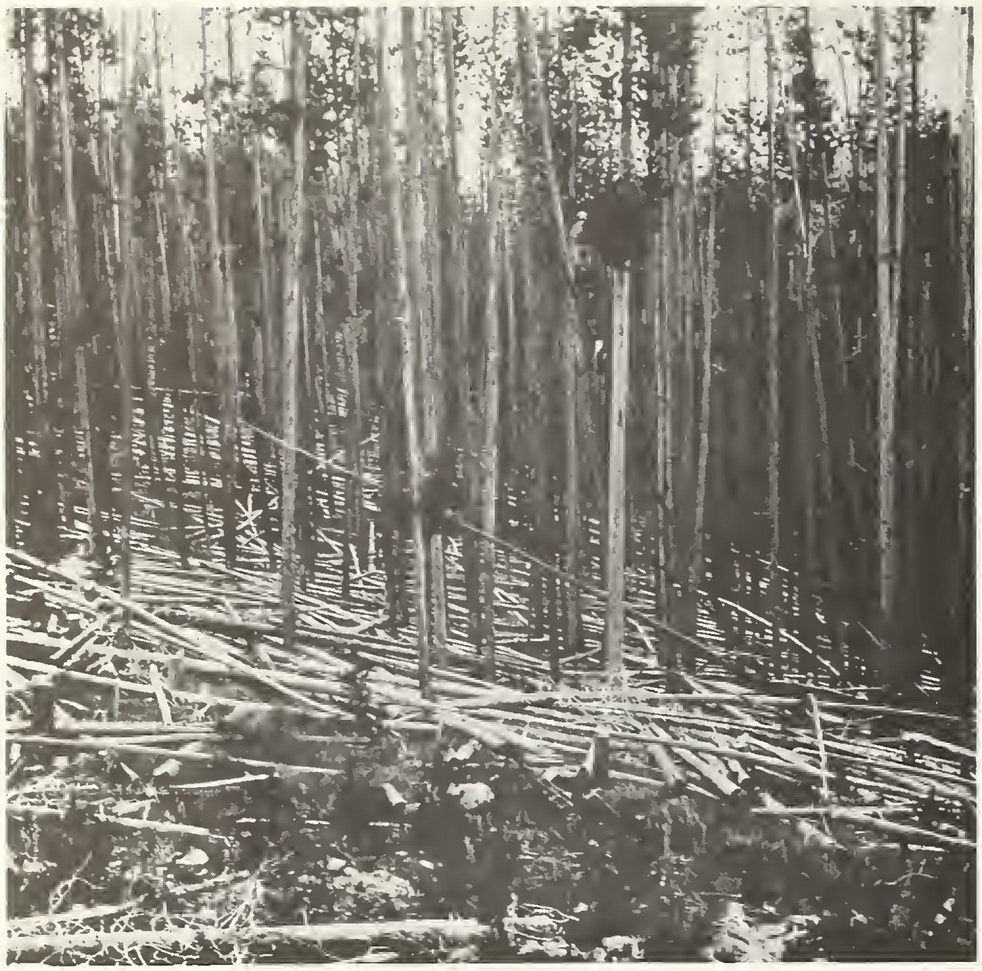


Figure 1.--Typical residues in overmature lodgepole pine on the Bitterroot National Forest.

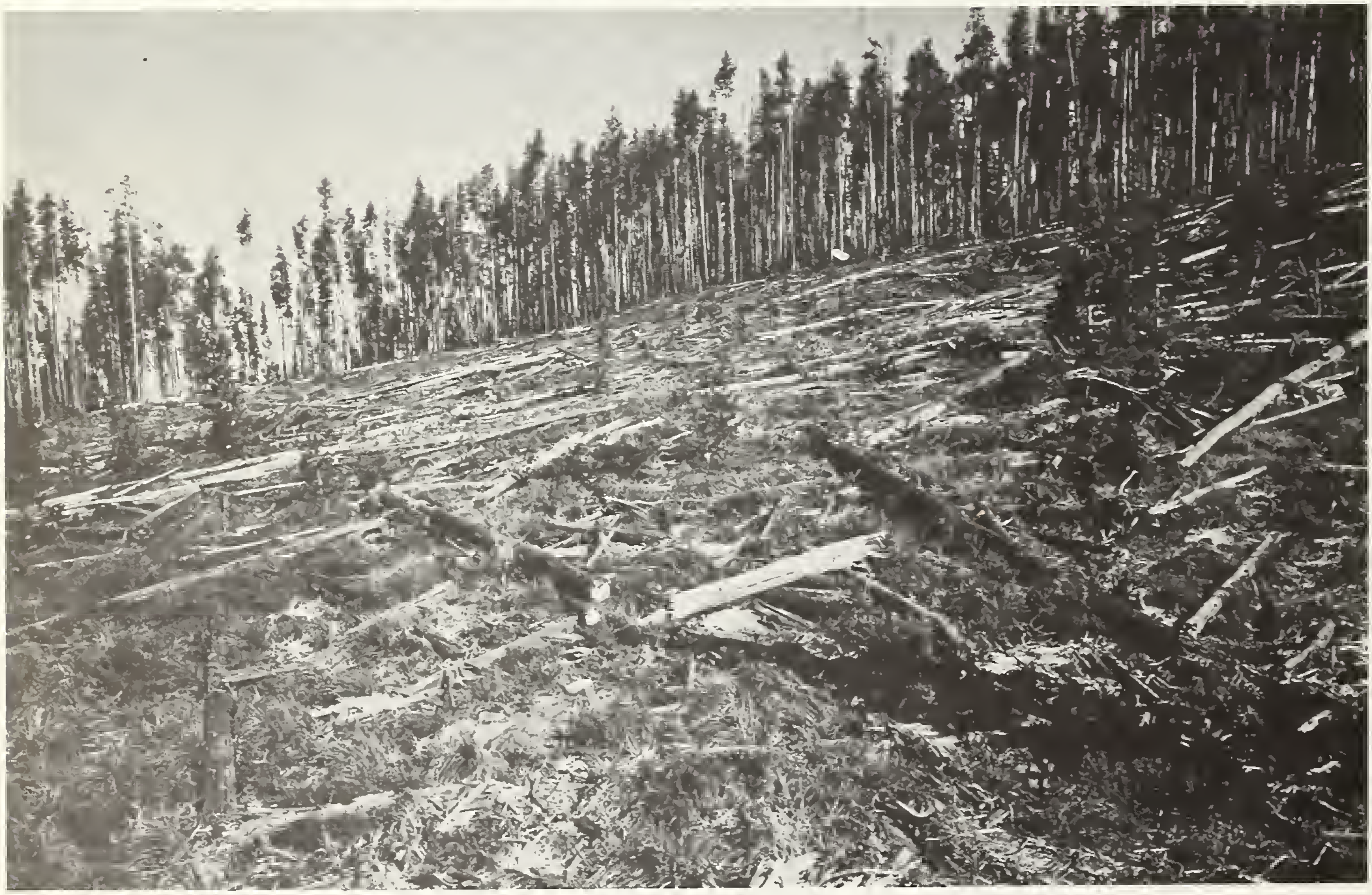


Figure 2.--Postlogging residue in overmature lodgepole pine stand.

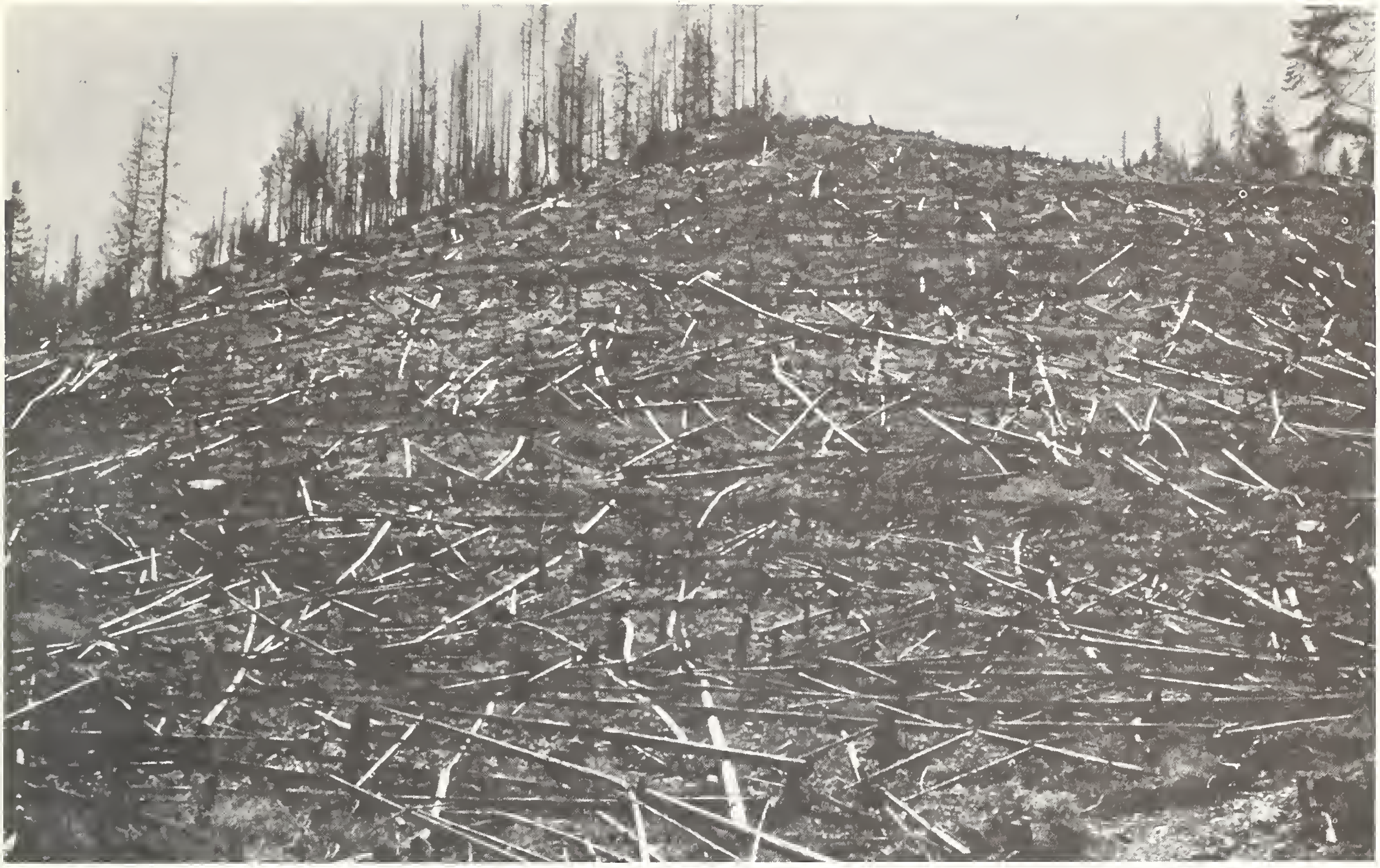


Figure 3.--Logging residues, after burning slash, on mixed spruce/fir type in western Montana.

CHIP DEBARKING SYSTEM

The debarking system consists of presteaming, compression debarking, optional mechanical attrition, with intermediate and final screening (fig. 4). Presteaming conditions the barky chips and improves bark removal during the compression debarking stage. Presteaming improves the bark removal by as much as 100 percent over unsteamed chips, depending on species and time of the year the trees were harvested.

The compression debarker consists of two steel rolls. By adjusting the position of roll stops, a predetermined nip spacing can be set between the rolls. Two hydraulic cylinders hold the adjustment roll in place and control the degree of compression to which the chips are subjected. The surfaces of the two compression rolls can be varied. In the initial tests conducted with the Intermountain species, one smooth and one knurled roll were used.

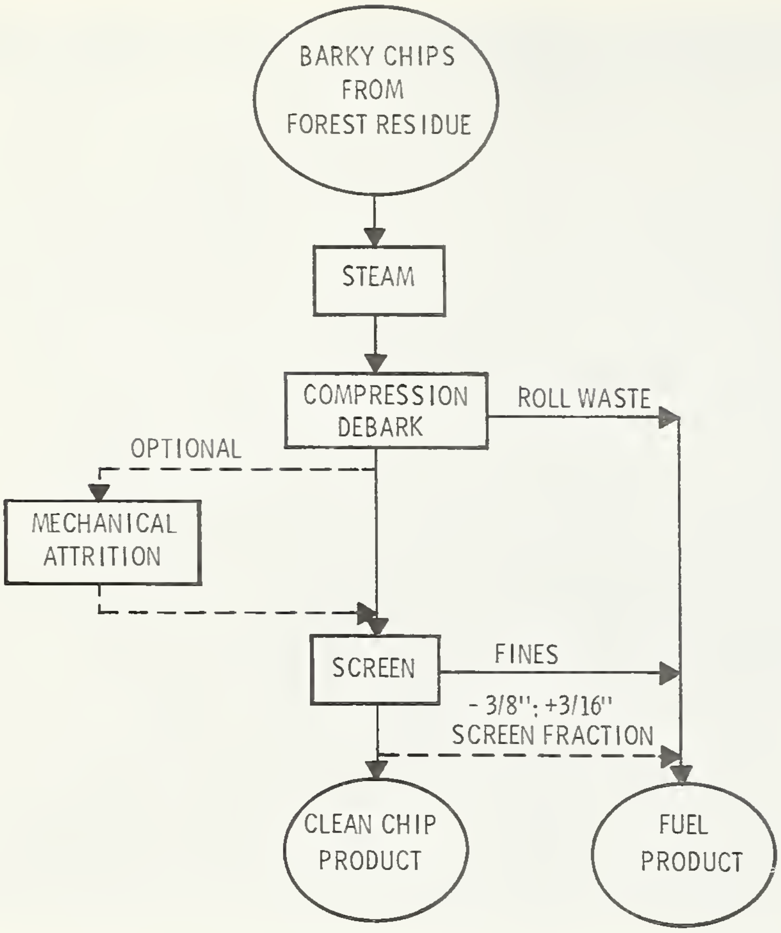


Figure 4.--Flow chart of system for upgrading barky chips produced from forest residue.

Bark removal is caused by bark adhering to the compression rolls where it is scraped off and collected. Additionally, some of the bark is fragmented into fines and removed by screening. The optional mechanical attrition process can be used to break down an additional amount of bark into fines for subsequent removal in the final screening stage.

The chip debarking efficiency is indicated by:

1. Bark content--a percentage of total chip output.

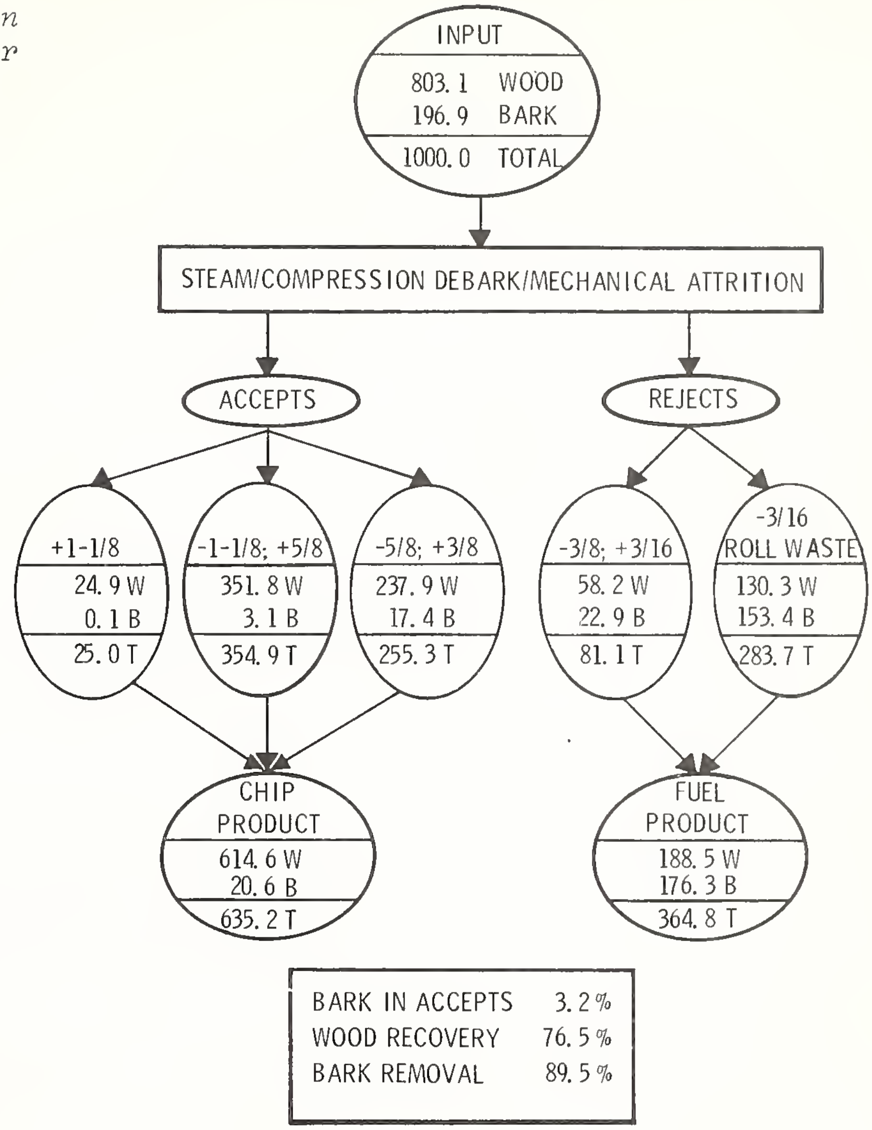
2. Debarking ratio--the ratio of output bark to input bark.

3. Percent wood loss--the amount of wood fiber lost as fines and adherence to the rolls.

Chip screens of 3/16-, 3/8-, and 5/8-inch openings are used to measure chip quality. Fines, material under 3/16 inch in size, can be used for fuel or other uses; chips over 1-1/8 inch are rechipped. Retained chips are used for pulping.

Initial tests with Intermountain residues were done with one smooth roller and one knurled roll. Figure 5 shows the average results based on 1,000 pounds of chipped material. Wood loss for these tests was generally high, much of it being attributed to the knurled roll.

Figure 5.--*Material balance based on average chip debarking results for several species of Intermountain logging residue (green material only).*



A second test of Intermountain species was undertaken as part of the Wyoming Residue Study (Gardner and Hann 1972). The chips were produced from logging residues, were stored for 1 year, and then were processed through three different levels of chip debarking treatments (table 1). A slight improvement over the previous study was found. Overall, the output bark content for all three treatments was around 2 percent.

Table 1.--*Debarking of lodgepole pine chips from Wyoming Residue Study*

Process code[1]	Input bark	Output bark	Output/input ratio	Wood loss
	- - - - *Percent*	*- - - -*		*Percent*
C	8.1	2.1	0.26	14.6
SC	8.9	2.0	.23	20.5
SCD	9.8	1.8	.19	21.3

[1] C - compression debarking.
SC - steaming and compression debarking.
SCD - steaming, compression, debarking, and drubbing.

FOLLOWUP TESTS

The promising bark removal results obtained in previous studies prompted a followup study having the goal of reducing wood fiber loss while maintaining or improving the level of bark removal. Because much of the wood loss in the initial study was attributed to the knurled roll on the compression debarker, the followup tests were done with smooth rolls. Roll nip spacing was 0.020 inch. Nip pressure was adjusted to approximately 1,400 pounds per lineal inch.

Green logging residues of the four species chipped in the initial study were used in the followup study. The presence of considerable bark within each size fraction indicated that screening alone would not separate sufficient quantities of bark from wood chips. Therefore, only those chips passing through the 1-1/8 inch screen but retained on the 3/16-inch screen were processed.

The chips were analyzed for bark content within each size fraction after processing (table 2). With all four species, the 5/8-inch screen fraction had less than 1 percent bark and represented about one-third to one-half of the total chip output. The 3/8-inch screen fraction represented close to an additional 40 to 50 percent of the chip output, with a residual bark content ranging between 1 and 6.5 percent. The 3/16-inch screen fraction had the highest residual bark content, ranging between 5 percent and slightly over 20 percent. However, this small screen fraction represented only 10 to 20 percent of the output.

When the retained screen fractions for each species were mixed together, the output bark content was 1 percent for lodgepole pine and 7 percent for western larch. Bark removal ranged from 60 to 85 percent and the wood loss between 8 and 13 percent (table 2).

By rejecting the 3/16-inch screen fraction from the output (because of the high bark content), residual bark in the accept chips (+3/8-inch) was reduced considerably. Douglas-fir, lodgepole pine, and ponderosa pine all contained less than 2.5 percent bark, and western larch 4 percent. Rejecting this fraction doubled wood fiber losses--to a range between 16 and 28 percent.

This wood loss may not be intolerable, when one considers that this system allows for 70 to 85 percent wood fiber recovery at relatively low bark contents from material not being utilized. The rejected fractions can be used as fuel.

A materials balance was made based on 1,000 pounds of lodgepole pine chips containing slightly over 6 percent input bark (fig. 6). Output was classified into two categories--accepts and rejects. The accept chips were those retained on a 3/8-inch or larger screen. The reject material was the roll waste and all material passing a

Table 2.--*Chip debarking results for four Northern Rocky Mountain conifer species (in percent*[1])

Species	Process[2] code	5/8-inch Retained chips Wood	5/8-inch Retained chips Bark	5/8-inch Wood loss	3/8-inch Retained chips Wood	3/8-inch Retained chips Bark	3/8-inch Wood loss	3/16-inch Retained chips Wood	3/16-inch Retained chips Bark	3/16-inch Wood loss
Western larch	SCD	99.2	0.8	72.8	93.6	6.4	27.6	80.4	19.6	13.3
Western larch	SCD	99.5	.5	72.4	95.4	4.6	25.2	84.2	15.8	10.1
Douglas-fir	SCD	99.5	.5	69.2	96.1	3.9	23.3	83.6	16.4	10.8
Douglas-fir	SCD	99.7	.3	66.8	95.7	2.5	22.3	81.7	18.3	11.0
Ponderosa pine	SCD	99.7	.3	59.5	97.5	[3]2.1	22.7	77.1	22.9	8.5
Ponderosa pine	SCD	99.8	.2	69.8	97.6	2.4	22.7	78.7	21.3	7.1
Ponderosa pine	SCD	99.7	.3	67.9	97.6	2.4	21.2	79.0	21.0	7.3
Ponderosa pine	SCD	99.7	.3	73.4	97.2	2.8	22.4	80.2	19.8	7.7
Lodgepole pine	SC	100.0	.0	48.6	99.1	.9	14.6	94.6	5.4	7.4
Lodgepole pine	SC	99.7	.3	59.8	98.7	1.3	18.1	95.2	4.8	8.2
Lodgepole pine	SC	99.7	.3	55.8	98.8	1.2	18.1	95.9	4.1	8.9
Lodgepole pine	SC	99.7	.3	54.6	99.1	.9	21.2	94.2	5.8	13.6

[1] Wood loss is expressed as percent of total wood input. The retained chips then amount to the percent of total chip quantities retained above the specified screen opening size. The wood and bark components are expressed as a percent of the total retained chip fraction.

[2] S = steamed 5 minutes; C = compressed; D = drubbed.

[3] 0.4 percent combined bark wood not included.

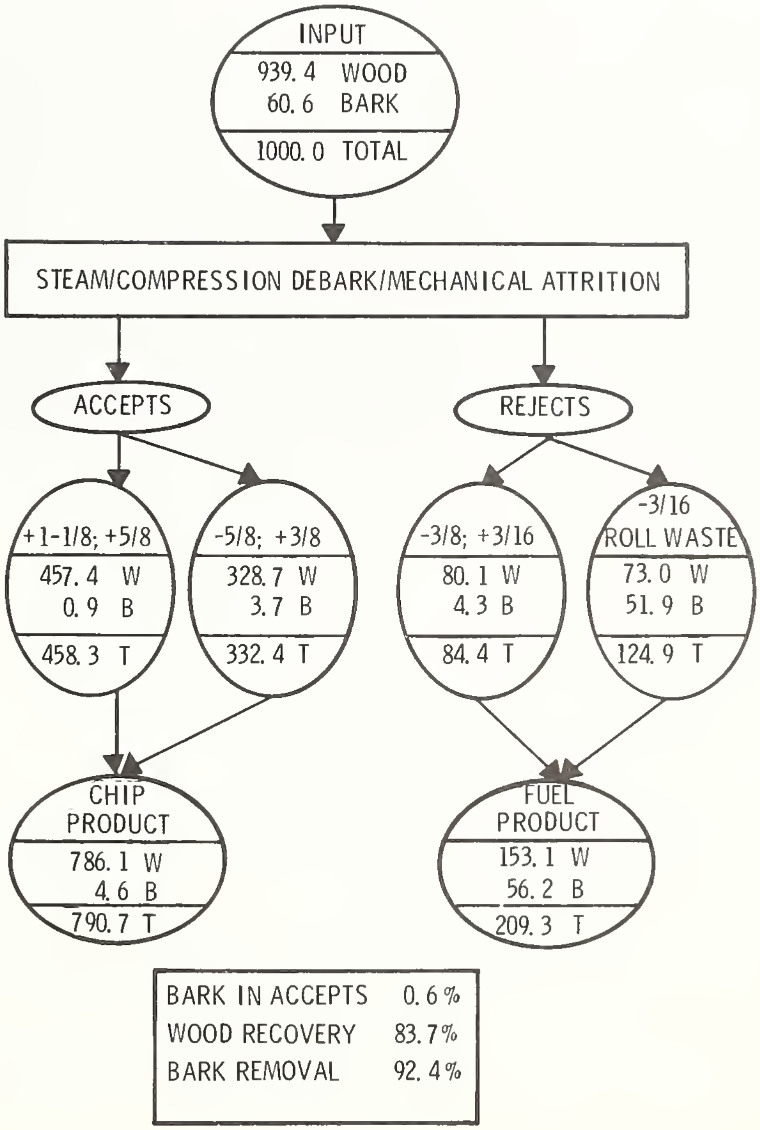


Figure 6.--Material balance for lodgepole pine (green) based on a 1,000-pound input.

3/8-inch screen after compression debarking. In summary, the material balance for lodgepole pine under the stated conditions would indicate that 790 pounds of chips would be accepted for pulping at a residual bark content of 0.6 percent. Or, 92.4 percent of the input bark was removed with 83.7 percent wood recovery.

About 210 pounds of material was rejected of which one-fourth was bark. Figure 7 shows the relative proportions of each size fraction and roll reject.

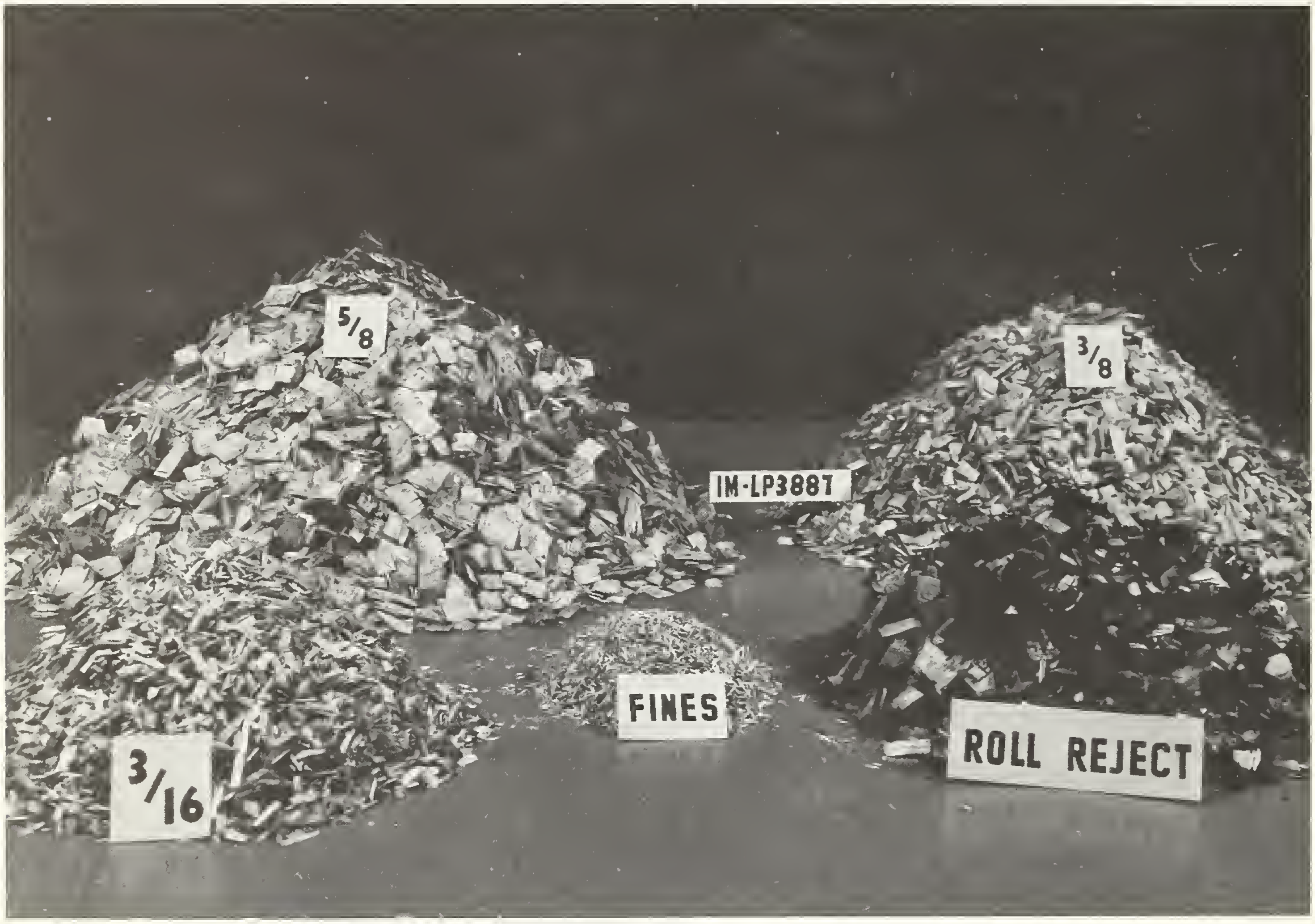


Figure 7.--Typical proportions of materials in final separation of chipped lodgepole pine.

APPLICATION OF CHIP DEBARKING TECHNOLOGY

Montana and Idaho annually produce 892 million cubic feet of chippable logging residue. Access and development costs have already been borne by the saw logs or thinning contracts. Road-access standards in many cases would permit chipping operations for the recovery of these residues. The degree of utilization of chipped residues, however, is dependent on debarking of wood chips. What then would be the impact of the chip debarking technology on the chipped residues?

The annual chippable residue of 892 million cubic feet converts to 13.4 million tons of wood and bark at 30 pounds per cubic foot, bone dry. Recognizing that it would be unrealistic as well as uneconomical to recover and process all the residue material under even the most favorable market conditions, only 10 percent, or 1.3 million tons of material will be assumed recoverable in the following example. This represents over 1 million bone-dry units at 2,400 pounds per unit.

To illustrate the impact of this chip debarking technology on Intermountain area logging operations and chip supplies, the following example is presented.

To simplify the example the following assumptions are made:

1. A modest 10 percent residue utilization level is rounded to 1.2 million tons.
2. Material loss is zero in the chipping and compression debarking processing. (All material is utilized for pulp or fuel.)
3. Accept wood chips size is +3/8 inch in the chip debarking process.
4. Wood fiber recovery from the debarking process is 80 percent.
5. The residual bark component in processed chips is as follows for total output:

Lodgepole pine	0.5 percent of wood
Ponderosa pine	1.4 percent of wood
Douglas-fir	2.3 percent of wood

6. The total residue volume of 1.2 million tons is equally distributed among the three species, lodgepole pine, ponderosa pine, and Douglas-fir.

Assuming equally proportioned distribution of the three species, table 3 shows the extrapolated recovery of saw log residues in Montana and Idaho: 843.3 thousand tons of clean chips for pulping and 357.7 thousand tons available as fuel.

Table 3.--*Annual recovery from Intermountain area saw log residue, in thousand bone-dry tons*

Residue form	Lodgepole pine	Ponderosa pine	Douglas fir	Total
	Thousand bone-dry tons			
Raw chips				
Wood	372	336	332	
Bark	28 (7%)	64 (16%)	68 (17%)	
Processed chips >3/8"				
Wood	297.5	268.8	265.5	
Bark	1.5 (0.5%)	3.8 (1.4%)	6.2 (2.3%)	
Total	299.0	272.6	271.7	843.3 70.3%
Residue				
Wood	33.8	67.3	66.4	
Bark	67.2	60.3	61.9	
Total	101.0	127.4	128.3	357.7 29.7%
Total	400	400	400	1,200 100%

1. Because chip values and fuel values vary geographically, it is impossible to give an accurate value. However, if we assume clean chips to be worth $40 per dry ton and fuels to bring $10 per dry ton, the debarked chips would have a net value of about $30.6 million after deducting an estimated $5.10 per dry ton for debarking. Barky chips would bring less than $12 million as fuel.

2. Aside from the increase in value, roundwood supplies would be extended by the equivalent of the 843,000 dry tons of usable chips, and additionally, 357,000 dry tons of fuel with a gross heat potential of about 6.1 trillion Btu would be available. For mills subject to interruptable energy supplies, this added fuel source could be important.

3. The increased value of chipped saw log debris could very easily increase salvage activity so that the utilization rate will exceed the 10 percent assumed in the example. As with primary mill residue, some of the cost of harvesting and chipping logging residue can be borne by the sawtimber operation.

4. Removal of wood residues in road construction would lower the fire risk along roads and would provide a considerable cost saving in road construction because right-of-way slash can be windrowed for removal during the chipping operation.

5. Provide incentives for multiproduct logging.

CONCLUSIONS

A system has been developed to debark chipped forest residues. Research showed that the process worked well on barky chips produced from whole trees of several tree species. The system consists of steaming, compression debarking, drubbing, and a final screening to remove fines.

The purpose of this study was to evaluate the technical feasibility of removing bark from chipped logging residues in the Intermountain area. It was found that the process definitely shows promise for upgrading a large percentage of barky chips produced from typical logging residues. Study results indicated 70 to 80 percent of the wood fiber could be recovered from freshly chipped (green) logging residue, with residual bark contents of 3 percent or less.

If only 10 percent of the available logging residues in the Intermountain region were harvested each year, more than 1.3 million dry tons of material would be available to industry. If this entire amount of material were converted to barky chips and then debarked by this system, approximately 843,000 dry tons of clean chips can be recovered for pulp and paper, and the remaining 357,000 dry tons used as fuel.

Utilization of this residue material would counteract mounting public objection to present utilization standards and disposal practices. Logging residues would be considered a resource--not waste.

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Woods-run samples of four Intermountain species (western larch, Douglas-fir, ponderosa pine, and lodgepole pine) were chipped separately, then processed through the chip debarking system developed by the Forest Service's Forest Engineering Laboratory at Houghton, Michigan. When the chips retained for each species were mixed together, bark content ranged from 1 percent for lodgepole pine to 7 percent for western larch. Bark removal ranged from 60 to 85 percent, wood loss from 8 to 13 percent.

OXFORD: 331:332.3:361.0.
KEYWORDS: residue utilization, raising chip value, chip bark removal.

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Headquarters for the Intermountain Forest and Range Experiment Station are in Ogden, Utah. Field programs and research work units are maintained in:

- Billings, Montana
- Boise, Idaho
- Bozeman, Montana (in cooperation with Montana State University)
- Logan, Utah (in cooperation with Utah State University)
- Missoula, Montana (in cooperation with University of Montana)
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